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STUDIES ON THE BIOLOGY OF THE ARIZONA WILD COTTON WEEVIL.[1]

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INTRODUCTION.

Early in 1913 it was announced by Mr. O. F. Cook of the Department of Agriculture that a weevil, apparently identical with the Mexican cotton boll weevil (*Anthonomus grandis* Boh.), had been found breeding in the fruit of a wild cotton plant (*Thurberia thespesioides*) in the mountains of southeastern Arizona.[2] This announcement was at once followed by explorations in Arizona to determine the distribution of the weevil and its host plant, and research work on the habits, life history, and economic importance of the species. Specimens were sent to the writer at Victoria, Tex., during the summer of 1913, and there as many as possible of their life functions were tested in comparison with the native weevils. Taxonomic study of the Texas and Arizona weevils showed the latter to be a distinct variety, and it was described by Mr. W. Dwight Pierce as *Anthonomus grandis thurberiæ*.[3] The biological investigations showed

[1] *Anthonomus grandis thurberiae* Pierce.

[2] Cook, O. F. A wild host plant of the boll weevil in Arizona. *In* Science, n. s., v. 27, no. 946, p. 259–261, Feb., 1913.

[3] Pierce, W. D. The occurrence of a cotton boll weevil in Arizona. *In* U. S. Dept. Agr., Jour. Agr. Research, v. 1, no. 2, p. 89–96, Nov. 10, 1913.

Note.—The investigations on which this paper is based were conducted under the direction of W. D. Hunter, in charge of Southern Field Crop Insect Investigations.

the two forms to interbreed very readily, however, thus demonstrating their very close relationship.

The biology of this weevil as studied at Victoria has been discussed in two papers.[1]

In the spring of 1914 the writer was stationed near Tucson, Ariz., where he studied the Thurberia weevil and its host plant under their natural conditions. These studies consisted of biological investigations similar to those conducted in Texas as well as the consideration of the possible and probable economic importance of the weevil in the arid West. The economic phases of the problem have been dealt with in another report,[2] so they will be only very briefly mentioned in the present paper.

The principal object of this report is to afford a comparison of the life functions of the weevils as performed by: (1) Texas cotton weevils at Victoria, Tex.; (2) Arizona Thurberia weevils at Victoria, Tex.; and (3) Arizona Thurberia weevils in Arizona. The first two subjects have already been covered in the papers previously mentioned and the last is discussed in the present paper. By a proper consideration of the activity and adaptability of the different forms of weevils under the same environmental conditions and of the same form of weevil under the different conditions it is possible to determine much of importance concerning the exact relation of the two varieties and the extent of variation and adaptation to be expected from each.

For the Arizona studies a camp was established at the Agua Caliente Ranch, about 18 miles east of Tucson. This ranch is located in the foothills of the Santa Catalina Mountains, near the eastern end of the range, at about 2,800 feet elevation. The various breeding experiments described were conducted in this tent while the field tests were located on the near-by irrigated land. These studies were continued from April 16, 1914, to November 16, 1914.

DISTRIBUTION OF THE THURBERIA PLANT AND WEEVIL.

The weevil is not known to occur on any plant other than Thurberia in Arizona, and it seems so closely linked with this plant that every Thurberia plant may be considered as a potential host for the species even though all of these plants do not harbor weevils now. Consequently knowledge of the distribution of the plant is of great importance in the study of the weevil.

The distribution of the Thurberia plant is but imperfectly known at present. Explorations have been made in Arizona by Mr. Vernon Bailey, Prof. J. J. Thornber, Mr. O. F. Cook, Dr. A. W. Morrill, Mr.

[1] Coad, B. R., and Pierce, W. D. Studies of the Arizona Thurberia weevil on cotton in Texas. *In* Proc. Ent. Soc. Wash., v. 16, no. 1, p. 23–27, Mar., 1914.

Coad, B. R. Recent studies of the Mexican Cotton Boll Weevil. U. S. Dept. Agr., Bul. 231, 34 p., Aug. 2, 1915.

[2] Coad, B. R. Relation of the Arizona Wild Cotton Weevil to Cotton Planting in the Arid West. U. S. Dept. Agr., Bul. 233, 12 p., 4 pl., May 27, 1915.

W. Dwight Pierce, Mr. E. A. Schwarz, and Mr. H. S. Barber, but the only data we have concerning the occurrence of the plant in Mexico are the records found with the specimens in the various herbaria.

The various explorations in Arizona have shown the plant to be present in the following localities: Santa Catalina, Santa Rita, Tanque Verde, Rincon, Mule Pass, Huachuca, Chiricahua, Superstition, Bradshaw, Dos Cabezos, and Dragoon Mountains, Globe, and Fish Canyon of the Salt River Valley. (Fig. 1.) So far the plant has not been located in any of the mountain ranges west of Tucson, but explorations have been conducted in only two or three of these and it is quite possible that it occurs there.

The writer is indebted to Mr. F. L. Lewton, of the Division of Textiles, United States National Museum, for a copy of the data on the specimens of this plant in the following herbaria: Gray Herbarium of Harvard University; Herbarium of the New York Botanic Garden; Columbian Herbarium, New York Botanic Garden; Herbarium of the Academy of Natural Sciences of Philadelphia; and the United States National Herbarium.

Many of the locality names noted on these are now obsolete and are very difficult to locate, but a general idea of the Mexican distribution of the plant may be secured. Fronteras, Oputo, Tunicachi, and Babusac, all in the State of Sonora, seem to indicate that the plant extends along the mountain ranges in the eastern part of this State and connects with the various localities noted in southwestern Chihuahua. From this point it seems to follow the ranges down at least as far as a point near Guadalajara, Jalisco, Mexico. This is the most southern record the writer has been able to discover.

So far the weevil has been found only in the Santa Catalina, Rincon, Santa Rita, Tanque Verde, and Dos Cabezos Mountains. Of these ranges the first four adjoin the Santa Cruz Valley, in which Tucson is located, and the last is near Bowie. In the examination of the plants found in the other ranges of the State, no signs of weevils were found but the distribution is certainly more general than that now known. Further explorations will probably demonstrate the presence of the weevils in other mountain ranges, at least in the southeastern part of the State.

We have no information concerning the presence of the weevil on Thurberia in Mexico, but the writer believes that it will be found extending all along the mountain chain through eastern Sonora, western and southwestern Chihuahua, and then probably connecting directly with the central Mexican territory in which the weevils live on cotton.

HABITAT OF PLANT AND WEEVIL.

The studies of the past season were confined to the mountains around Tucson and the most thoroughly worked of these was the Santa Catalina Range, where the local distribution of the plant and

weevil was studied in detail throughout the range. In this range the Thurberia plant was found, scatteringly but very generally, at altitudes ranging from about 2,600 to 7,000 feet. The writer, working

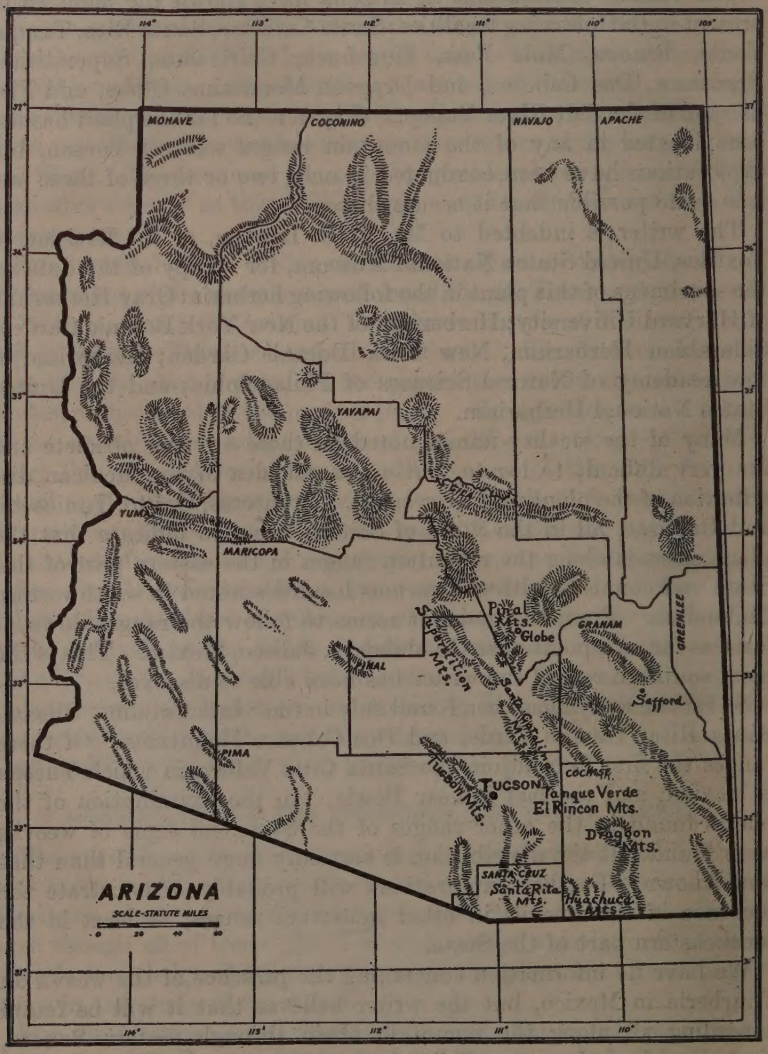

FIG. 1.—Map of Arizona showing mountain ranges representing the habitat of the Arizona wild cotton weevil (*Anthonomus grandis thurberiae*) and its food plant (*Thurberia thespesioides*). (Original.)

along the southern and southwestern slopes from the divide at the eastern end to the western tip of the range, practically circled the range. From the western tip of the range trips were made around the western end into the northwestern slopes at Montrose and Romero

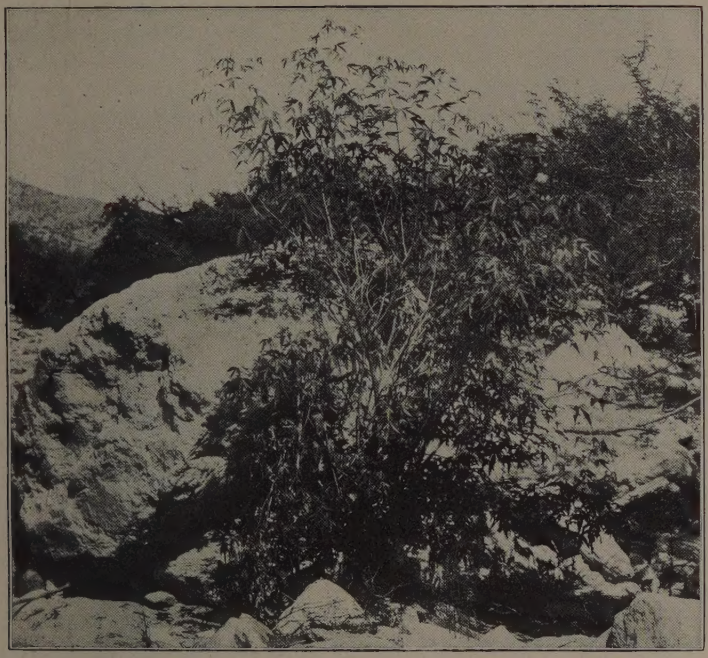

FIG. 1.—DISPERSION OF THE WILD COTTON WEEVIL.

Typical location of Thurberia plant, below rock, in Agua Caliente Arroyo, Ariz., about 1½ miles from the mouth of the canyon. (Author's illustration.)

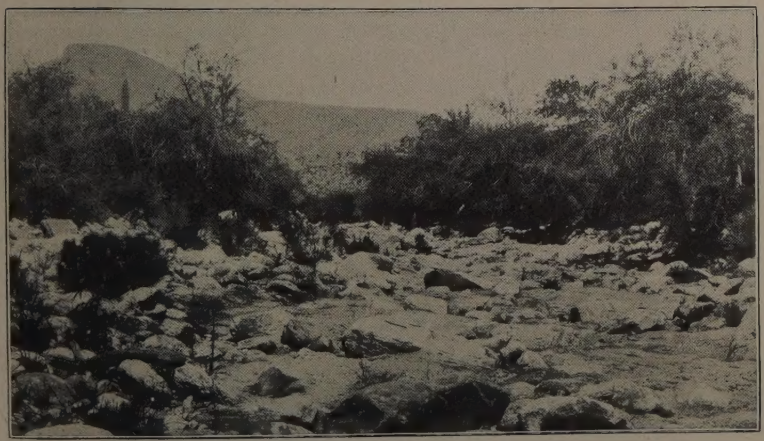

FIG. 2.—THE WILD COTTON WEEVIL AND ITS HOST PLANT IN THE LOWER RANGES.

Habitat of *Thurberia thespesioides* and the wild cotton weevil in the lower ranges. This view was taken in the Agua Caliente Arroyo, Ariz., about 100 yards below the plant shown in figure 1. (Author's illustration.)

THURBERIA THESPESIOIDES, THE FOOD PLANT OF THE ARIZONA WILD COTTON WEEVIL, ANTHONOMUS GRANDIS VAR. THURBERIÆ.

Canyons and nearly to Oracle. The writer then crossed the range by the trail above Agua Caliente Canyon, descended into the San Pedro Valley on the northeastern side, and explored the slopes. Combined with these observations numerous trips back and forth throughout the range were made at various points which gave comparatively thorough data on the internal conditions of the mountains.

Thurberia plants were found at intervals throughout this territory. Summarizing these observations it seems impossible to name any certain type of situation as the normal habitat of the Thurberia plant, since it is found in moist canyon beds, in dry arroyos, on dry slopes, and on the top of peaks. However, by far the greater number of plants are located in canyon beds, mountain washes, or arroyos out through the mesa, and in searching a new locality these are usually the most frequent situations in which the plant is found. Thurberia plants growing under these conditions usually develop a more healthy growth than those on the more exposed slopes, and usually the plants at higher altitudes, on slopes and peaks, are found more or less grouped in colonies. Travel for miles through such territory may not disclose a single plant when suddenly colonies of from three plants to several dozens are found. The distribution in canyon beds and washes, however, is quite different, for here the plants are usually found more or less scattered and growing singly, although in many canyons a plant will be found every few yards for several miles. (Pl. I, figs. 1, 2.) Occasionally, in locations particularly well sheltered from the force of the current, a large colony of plants may be found, but such cases are infrequent.

At lower altitudes, on the mesa and plains, Thurberia plants were found extending along the dry arroyos often to a distance of several miles from the base of the mountains. Here, while fairly common, they are scattered, being found along the margin of the channel, on small islands, or in protected situations behind rocks.

The occurrence of the Thurberia plant at an elevation of 7,000 feet was not noted until late in the season, at which time a few were found on a peak at about this elevation, behind Soldiers Canyon. It is interesting to note that one specimen in the Gray Herbarium and another in the Herbarium of the Academy of Sciences of Philadelphia, both collected by Edw. Palmer, bear the following data: "The Frailes above Batatopas, S. W. Chihuahua, Mexico, 7000 feet alt. October."

Back in the interior of the Santa Catalina range in the small canyons draining this country the plants were found to be quite common along the stream beds.

The Arizona wild-cotton weevil was found to be as widely distributed throughout this range as was the Thurberia plant, but the weevils were by no means present on all plants. While the weevils

were found in all types of situations at altitudes from about 2,750 feet to 7,000 feet, they were more abundant on plants growing at elevations of from 3,500 to 5,000 feet. The writer has been unable to determine any type of location as being especially favorable to the maintenance of the weevils.

In the Santa Rita Range the writer confined his studies almost entirely to points of less than 4,000 feet elevation. The country examined was that which lies along the base of the mountains commencing at a point below Madero Canyon and extending nearly to the northern end of the Santa Rita Range. Throughout most of this country the Thurberia plant was found extending down the arroyo nearly to the 3,000-foot level, and weevils were located on many of these plants at this elevation.

Very little exploring was done in the Tanque Verde Mountains, but a few trips were made on the northwestern slope above the village of Tanque Verde, where a few plants, some bearing weevils, were located in the "washes" of this comparatively regular slope.

In the Rincons the investigation was limited to the examination from the southern end of the range of some of the lower arroyos which form the headwaters of the Pantano, and Thurberia plants and a few weevils were found. Messrs. Barber and Schwarz found plants and weevils on the Manning trail above Mills ranch and Prof. Thornber reported a colony from a short distance above the Shaw ranch.

Investigation seems to have established that the Thurberia plant does not occur in the Tucson Range, as this range was explored by Dr. A. W. Morrill and Mr. W. Dwight Pierce during the summer of 1913 with negative results, and a search made by the writer in September, 1914, also proved negative. This range seems far too dry for the existence of the Thurberia plant.

SEASONAL ACTIVITY OF PLANT AND WEEVIL IN NATURE.

As the activity of the Arizona wild-cotton weevil in nature is largely dependent upon the growing and fruiting period of the plant, close observations were made, particularly in relation to the time of fruiting. These observations showed the time to vary greatly with the location of the plant, and the most important factor seems to be altitude and its accompanying conditions. The plants observed closely during this season ranged from 2,700 to 5,000 feet, and while no definite lines can be drawn, the following discussion gives the variations in time as they were noted at the different elevations.

Plants growing in the channels of Milagroso, Agua Caliente, and Soldiers Canyon and in the arroyos below these canyons (elevation below 3,000 feet) were all leafed out and squaring heavily by the 1st of May. They began blooming about May 7. After two or three weeks of flowering the buds ceased to appear and there was a

quiet period during which the bolls ripened, opened, and shed their seeds. Then another crop of buds appeared and the same course was repeated. In this manner as many as four crops of fruit were produced by some of these lower plants and many produced three.

Higher in the canyon channels and on the lower slopes (elevation 3,000 to 4,000 feet) the plants started to square shortly after the 1st of June and produced two or three crops before the end of the season. They all began leafing out about the same time as the lower plants just discussed.

About the 1st of July the plants growing at about 4,500 feet started squaring while those above 5,000 feet did not start until July 30 or later, and produced only one crop.

From this is seen the extreme variation in the fruiting period of the plant. This grouping by altitude is of course only approximate because the conditions (moisture, exposure, etc.) vary greatly at the same altitude in different locations.

The active period of the plant will probably vary with the different years according to climatic conditions. The winter of 1913–14 was exceptionally mild and consequently some of the lower plants may have started blooming earlier this season than is usual.

Regardless of the previous activity of the plants, the last crop of fruit (produced during August and September) is always the largest and blooming extends over a longer period at this time. Most of the plants stopped blooming during the latter part of September though quite a few continued blooming into early October.

The appearance of the weevils from hibernation is very scattering during the early spring months. The first record of emergence during the spring of 1914 was an individual noted in a branch of Agua Caliente Canyon at about 3,000 feet altitude on May 10. Following this a few were found active here and there in the mountains, but they were not common until later in the season.

These early individuals fed upon the squares and bolls present, and produced a few progeny in the latter. The resulting weevils emerged after a normal developmental period and aided in the infestation of the large crop of fruit in August and September.

The general emergence of the weevils began shortly after the first of July and by the middle of August nearly all weevils had emerged. These were all quite active on the plants after this time. During the past season the writer did not note a single weevil breeding in the buds of Thurberia, although considerable feeding upon them was observed. This is directly contrary to the conditions found by Mr. Pierce in August, 1913, when he observed the weevils breeding abundantly in Thurberia buds in both the Santa Catalina and Santa Rita Ranges. This discrepancy in records may be due to some differences in the seasonal conditions.

With the existing variations in time of emergence it is impossible to determine the exact number of generations per year, but most of the weevils seem to have only one or two, the last remaining in the pupal cells in the bolls and so hibernating.

The activity of the weevils seems to continue until stopped by the cold weather. It was greatly decreased in most places through October, but a few weevils were still active on the 1st of November.

EMERGENCE OF WEEVILS.

The study of the weevil activity in nature was greatly confused by the extreme variation in the time of emergence from hibernation. These weevils pass the winter in pupal cells in the Thurberia boll and, instead of emerging in the spring with the first warm weather, prolong the dormant period far into the season before leaving the cell. In fact, some individuals have been found in old cells as late as the 1st of September, though nearly all emerge during July and August. Because of the possible economic importance of this delayed emergence in relation to the transfer of the weevil from Thurberia to cotton, cage tests were conducted and careful observations made in the field to determine under what conditions the weevils will emerge.

For the cage tests a number of infested Thurberia bolls which had remained hanging on the plants since the fall of 1913 were collected in the upper part of Soldiers Canyon on June 6 and were kept in a dry box until the time of starting the tests.

The treatment of the different lots of infested bolls was as follows:

No. 1. Bolls not moistened placed in empty tumbler in shade.
No. 2. Bolls not moistened placed in empty tumbler in sun.
No. 3. Bolls not moistened placed on moist sand in shade.
No. 4. Bolls not moistened placed on moist sand in sun.
No. 5. Bolls immersed in water 1½ minutes and placed on moist sand in shade.
No. 6. Bolls immersed in water 1½ minutes and placed in empty tumbler in shade.
No. 7. Bolls immersed in water 30 minutes and placed on moist sand in shade.
No. 8. Bolls immersed in water 30 minutes and placed in dry tumbler in shade.
No. 9. Bolls immersed in water 30 minutes and placed on moist sand in sun.

These tests were started July 11, and each lot was examined at frequent intervals until September 22 and all emergence noted. Five bolls were placed in each lot. On September 22 all bolls were opened and the condition of the weevils inhabiting them noted.

From the unmoistened bolls placed in dry tumblers no weevils emerged. When the unmoistened bolls were placed on moist sand and left in the shade, two weevils emerged, but when they were placed in the sun none emerged. When the bolls were immersed in water for 1½ minutes and then placed on moist sand in the shade four emerged, but those moistened in the same manner and placed in a dry tumbler in the shade produced none. When immersed in water 30 minutes and left on moist sand in the tent three emerged and those moistened in the same manner and placed on moist sand

in the sun produced none. Those immersed 30 minutes and placed in a dry tumbler in the shade produced one weevil.

These results indicate the importance of moisture in the emergence of the weevils. Mere placing on moist sand caused some weevils to emerge in 5 days, but the bolls moistened and then placed on moist sand in the shade produced the maximum emergence. In the various lots which were placed in the sun not a single weevil emerged regardless of treatment. This was evidently due to the extreme heat in the tumbler. All weevils were found dead in these cells upon examination while many of those in the shade were still alive in the cells.

These experimental tests of the factors producing emergence are far from conclusive, but by combining them with various observations made in the field a fairly definite idea of conditions under which the weevils will emerge may be secured, and by studying the seasonal climatology of the region inhabited by the weevils it is possible to know when to expect the emergence.

The emergence of the weevil shows a very decided relation to the structure of the Thurberia boll and is the result of a gradual preparation of the boll which extends over a considerable period of time. In the fall the weevil cell is surrounded by the compact seeds and these in turn are inclosed in the covering of the boll. These soon dry and harden so that emergence is impossible. Then follows a slow changing of the boll extending through the winter months. The seeds around the cell ripen, harden, and separate slightly. The outer covering of the boll cracks apart at the apex and gradually splits toward the base. While this is largely a process of ripening and dessication, it is undoubtedly aided by the occasional rains during the winter and early spring. By spring the boll reaches a condition such that it is easily opened and the seeds scattered by a light crushing, but now the weevil cell itself holds the contents intact. In fact most of the uninfested bolls have opened wide by this time and the seeds have been blown and shaken out by the wind.

At this period it seems usually necessary for the boll to be at least slightly moistened to soften the cell before the weevil can emerge. The tests of the amount of moisture required to accomplish this show that it is variable and that very little is necessary in some cases.

That moistening is not always necessary to allow emergence is shown by the fact that the writer has observed weevils both in the field and in the laboratory emerging from perfectly dry bolls which had not been moistened for weeks. These cases seem to be due to the imperfect formation of the cell, which is weak enough to be broken by the drying of the boll and separation of the seeds.

From these observations concerning the importance of moisture in the emergence of the weevils, it seems quite probable that in the

vicinity of Tucson the normal emergence in the mountains is scattering during the spring and summer months, depending largely upon the frequence of the showers during this period, and that the general emergence is produced by the rains of July and August.

RELATIVE ATTRACTION OF COTTON AND THURBERIA FOR WEEVILS.

During the season a number of tests were made to determine the relative powers of cotton and Thurberia for attracting the weevils. Various types of weevils and different foods were used in the different lots but the method of procedure was identical for all.

Large, weevil-proof screen cages were used. They were placed on bare ground which was kept slightly moist by an irrigation ditch on each side of the row of cages.

In preparing the cage for the test the Thurberia plant was placed upright in one corner about a foot from the wall of the cage and the cotton plant was placed diagonally opposite. Then the weevils were released on the ground in the center of the cage. Following this, examinations were made frequently to determine the amount of feeding on each plant and the weevils present on each. All weevils found on plants were removed and released in the center of the cage. Fresh plants were placed in the cages almost every day or often enough to keep green food present at all times. In order to eliminate the influence of light from any selection the weevils might make, the positions of the plants were reversed daily.

All weevils were hibernated individuals which were removed from their 1913 pupal cells in Thurberia bolls. The observations may best be divided according to the food of the weevils before these were placed in the test cages.

WEEVILS NOT FED BEFORE TESTING.

On the 1st of August 14 males and 14 females removed from bolls collected in December, 1913, in the Santa Rita Mountains were placed immediately in a cage with cotton and Thurberia plants bearing neither squares nor bolls. On August 24 plants with squares and bolls were started and continued as the food for the remainder of the experiment.

Feeding began immediately on both plants and was continued more or less constantly until the close of the experiment on September 17. For the first 15 days the feeding was mostly on Thurberia, but after that time cotton was more or less favored. The summary of the observations for the entire period is as follows:

Cotton attacked	records	24
Thurberia attacked	do	16
Weevils on cotton, 3 male, 21 female	total	24
Weevils on Thurberia: 3 male, 14 female, 2 of sex not determined	total	19

From this it is seen that more weevils were observed on cotton and there was also more feeding on this plant than on Thurberia in the course of the entire experiment. At the very beginning what seemed to be a preference in favor of Thurberia was noted, but this disappeared later.

On the 4th of August 13 females and 12 males were removed from cells in Thurberia bolls collected in the Santa Rita Mountains in December, 1913, and kept almost entirely without food (cotton leaves fed only once) until August 7. They were then placed in a cage with Thurberia and cotton plants, both bearing buds and bolls. The experiment was continued until September 17 though the last feeding was noted September 11. Throughout this time a slight preference in favor of Thurberia was maintained and the summary of observations is as follows:

Cotton attacked	records..	7
Thurberia attacked	do....	13
Weevils on cotton, 3 male, 4 female, 1 of sex not determined	total..	8
Weevils on Thurberia: 7 male, 11 female, 1 of sex not determined	total..	19

These two tests of unfed weevils total as follows:

	Records.
Cotton attacked	31
Thurberia attacked	32
Weevils on cotton	32
Weevils on Thurberia	38

From these figures it is quite evidently useless to attempt to credit the weevils with a choice for either plant when unfed before testing.

WEEVILS FED UPON COTTON SQUARES BEFORE TESTING.

On the 24th of August 12 weevils of each sex were removed from the hibernation cells in Thurberia bolls collected in the Santa Rita Mountains December 4, 1913. These were fed upon cotton squares from this date until August 31 and then placed in a cage with cotton and Thurberia plants bearing buds and bolls. This test was continued until September 27 and the feeding continued until that date.

For the first few days a slight preference in favor of cotton was shown, but this soon disappeared and the feeding was much the same on the two plants for the remainder of the experimental period. The summary of observations is as follows:

Attacking cotton	records..	9
Attacking Thurberia	do....	7
Weevils on cotton: 8 male, 6 female, 1 sex not determined	total..	15
Weevils on Thurberia: 11 male, 6 female, 1 sex not determined	do...	18

From this feeding it is evident that, while the feeding upon cotton squares for the first few days after emergence may have caused a slight preference in favor of cotton plants early in the test, this did not last more than a very short time and then no preference was shown.

WEEVILS FED UPON THURBERIA BEFORE TESTING.

On August 24 another lot of weevils (11 males and 12 females) were removed from cells in Thurberia bolls collected in the Santa Rita Mountains December 4, 1913. These weevils were fed upon Thurberia buds and leaves until August 31 and then were placed in a cage with Thurberia and cotton plants, both bearing squares and bolls. Here the initial feeding showed a preference for Thurberia, but this was lost within a few days and the feeding became almost equal on the two plants. The test was continued until September 17 and feeding lasted until that time. The summary of observations for this lot is as follows:

Attacking cotton	records	7
Attacking Thurberia	do	6
Weevils on cotton: 5 male, 7 female	total	12
Weevils on Thurberia: 7 male, 11 female	do	18

SUMMARY OF ALL TESTS.

The summary of the results of the various experiments just detailed is given in Table I.

TABLE I.—*Relative attraction of cotton and Thurberia for weevils.*

Food before starting test.	Cotton.					Thurberia.				
	Plants attacked.	Weevils.				Plants attacked.	Weevils.			
		Male.	Female.	Sex not determined.	Total.		Male.	Female.	Sex not determined.	Total.
None	31	6	25	1	32	32	10	25	3	38
Cotton squares	9	8	6	1	15	7	11	6	1	18
Thurberia buds	7	5	7	.....	12	6	7	11	.....	18
Total	47	19	38	2	59	45	28	42	4	74

From this table it is seen that, while the cotton plants were attacked slightly more than the Thurberia, more weevils were observed on the latter. It is interesting to note that in the total of the observations of the weevils on both plants males were noted 47 times and females 80 times. As the weevils used were very nearly equally divided as to sex (49 males and 51 females), this seems an instance of the greater activity of the females.

These cage tests seem to indicate that unfed hibernated Thurberia weevils display no preference for either plant, while those fed on either plant exclusively for a few days after emergence will at first favor that plant slightly when offered a choice, but will soon feed equally on both. From this it would seem that neither plant has the power to attract the weevils away from the other, but later observations made in the field are rather contradictory to this. The field cotton at the ranch this season was repeatedly attacked by the weevils, and, while there was considerable injury to the squares and bolls on this cotton, only two bolls were attacked on

several Thurberia plants growing so close that some branches overlapped the cotton.

LIFE-HISTORY STUDIES.

FECUNDITY.

A number of series of Thurberia weevils were tested to determine the fecundity of the females on the different foods.

WEEVILS FED ON COTTON SQUARES.

During the season 14 pairs of weevils were mated on cotton squares in glass tumblers and the fecundity determined. These weevils either emerged from or were removed from their hibernation cells in Thurberia bolls collected at different points in the Santa Catalina and Santa Rita Mountains. They were all hibernated individuals. Nearly all were left on cotton squares until the close of the experiment, but two were removed from this food after 17 days and fed on cotton bolls for the remainder of the period.

Of the 14 females thus mated, 13 oviposited more or less normally. The other one, placed with cotton squares August 31, deposited one egg October 5 and another one October 7 and then stopped. This female was still alive and feeding at the close of the experiment on November 8. The data showing the activities of the 13 normal females are given in Table II.

Owing to the shorter active season to which the Arizona weevils are accustomed, it seemed quite probable that the average fecundity of the females would not equal that of the Texas weevils, but this is seen not to be the case. These averages secured with *thurberiae* on cotton squares in 1914 are very nearly as high as those from the best series of *grandis* reared in Texas on the same food in 1913, and they are higher than the general average of all series of *grandis*.

TABLE II.—*Fecundity of Anthonomus grandis thurberiae mated on cotton squares, Agua Caliente ranch, Arizona, 1914.*

Source of weevils.	Date first fed squares.	Date first egg.	Period fed squares to deposition.	Date last eggs.	Oviposition period.	Total eggs.	Average eggs per day.	Date female dead.	Date male dead.
			Days.						
Emerged from cells in Thurberia bolls	June 23	July 5	13	Aug. 10	36	176	4.9	Aug. 10	
Removed from cells in Thurberia bolls	June 25	July 15	20	Aug. 7	24	116	4.8	Aug. 7	
Do	July 8	July 12	4	Aug. 31	51	82	1.6	Sept. 14	July 12
Do	...do	July 13	5	Aug. 14	33	150	4.5	Aug. 11	Sept. 11
Do	...do	July 15	7	Aug. 19	36	126	3.5	Aug. 24	Aug. 14
Do	July 11	...do	4	Aug. 28	45	217	4.8	Aug. 30	Sept. 4
Do	...do	...do	4	Aug. 13	30	144	4.8	Aug. 14	Sept. 11
Do	Aug. 11	Aug. 21	10	Sept. 16	27	92	3.4	Sept. 19	
Do	...do	Aug. 20	9	Oct. 31	72	309	4.3		
Do	...do	Sept. 1	20	Nov. 2	62	299	4.8		
Do	Aug. 31	Sept. 12	12	Nov. 4	54	156	2.9		Oct. 31
Do.[1]	...do	Sept. 7	7	...do	59	39	.7		Sept. 12
Do.[1]	...do	Sept. 12	12	Oct. 19	38	141	3.7	Oct. 19	
Total			127		567	2,047			
Average			9.7		43.6	157.4	3.4		
Maximum			20		72	309	4.9		
Minimum			4		24	39	.7		

[1] These weevils were fed on squares until Sept. 17, and then on bolls.

The transfer of some of the weevils from cotton squares to cotton bolls late in life seemed to have no effect upon their oviposition as they continued ovipositing at about the same rate without a break.

It is interesting to compare the data presented in this table with the results secured by mating *thurberiae* on cotton squares in the same manner at Victoria, Tex., in 1913. Table III gives this comparison.

TABLE III.—*Comparison of results secured in Arizona and Texas with regard to fecundity of Anthonomus grandis thurberiae.*

	Average oviposition period.	Average eggs per female.	Average eggs per female. per day.	Maximum eggs per female.
	Days.			
Texas	32	103.0	3.2	173
Arizona	45.1	157.4	3.4	309

This table shows the greater fecundity of the variety under Arizona conditions than under the unnatural environment of southern Texas, although the daily rate of oviposition was much the same.

WEEVILS FED ON COTTON BOLLS.

Four pairs of hibernated *thurberiae* were removed from the cells in Thurberia bolls and mated on cotton bolls in glass tumblers in the same manner that others were mated on cotton squares. The results secured from these are shown in Table IV.

TABLE IV.—*Fecundity of Anthonomus grandis thurberiae on cotton bolls, Agua Caliente Ranch, Arizona, 1914.*

Source of weevils.	Date first fed bolls.	Date first egg.	Period fed bolls to deposition.	Date last egg.	Oviposition period.	Total eggs.	Average eggs per day.	Date female dead.	Date male dead.
Removed from cells in			*Days.*		*Days.*				
Thurberia bolls	July 13	July 20	7	Aug. 13	25	7	0.3	Aug. 24	July 19
Do	July 15	July 19	4	Aug. 10	22	64	2.9	Aug. 13	Aug. 17
Do	...do	...do	4	Aug. 17	29	84	2.9	Aug. 30	
Do	Aug. 11	Aug. 21	10	Oct. 14	55	190	3.4	Oct. 21	
Total			25		131	345			
Average			6.2		32.7	86.2	2.6		
Maximum			10		55	190	3.4		
Minimum			4		22	7	.3		

From this table it is seen that the weevils displayed a comparatively low degree of fecundity. This is seemingly in direct contradiction to the results secured in the series of weevils on live plants in the field and also of those offered a choice between cotton squares and bolls. Quite a number of tests in glass tumblers were made during the season to determine the preference displayed by the weevils in

relation to cotton bolls and squares. These all gave the same result, namely, that cotton bolls were much preferred to cotton squares. While there would always be some feeding upon the squares and an occasional egg would be deposited in them, by far the greater part of the feeding and deposition was on the bolls. In the field experiments where the weevils were placed on growing cotton plants there was some feeding on squares but the bolls received almost all of the feeding and deposition. In the breeding experiments where weevils were mated on squares for some time and then placed on bolls the oviposition continued through the change of food without diminution. In view of these observations it seems quite reasonable to believe that the cotton bolls are better suited to the weevil than the squares and hence it is hard to account for the much lower fecundity shown by the weevils in this boll-fed series than by those in the corresponding series fed upon squares.

WEEVILS FED ON THURBERIA.

At different times during the season weevils were removed from their hibernation cells in Thurberia bolls and mated in glass tumblers containing Thurberia leaves, squares, and bolls. For some reason these attempts to secure egg deposition were almost total failures. Nine pairs were mated in this manner and of these, seven females failed to deposit any eggs, one deposited a single egg, and the other deposited 66 eggs. This last female was placed with the food September 1, deposited the first egg September 23, and the last October 16, giving an oviposition period of 24 days. The average number of eggs per day was 2.7.

Some of the females which did not oviposit were allowed to live until their normal death, while others were killed after some weeks because of lack of food. It is difficult to determine the cause of this failure of the females to oviposit, but it is probably due to some fault in the breeding methods. One point which was noted in this connection was the extreme rapidity with which Thurberia bolls ripen after removal from the plant and hence become unfit for egg deposition. The seeds dry and harden very rapidly even though the boll is quite small. In such bolls the weevils will feed through the tender tissue near the stem end, but will not oviposit. The experimental conditions (cages, tumblers, etc.) were exactly the same as those for weevils upon cotton squares and bolls which were ovipositing normally at this same time, so the cause evidently was some fault with the condition of the food. Two females which were allowed to remain in tumblers with Thurberia bolls and squares for 14 days without oviposition were then transferred to living Thurberia plants in the field and they immediately began ovipositing.

DEVELOPMENTAL PERIOD.

IN COTTON SQUARES.

No observations were made on the length of the different immature stages in cotton squares, but the total developmental period was studied throughout the season from eggs deposited from July 6 to about the 1st of November. The squares were placed on moist sand in glass tumblers each day and the sand was kept damp. The date of the emergence of the adult was noted and the period between egg deposition and adult emergence was thus determined. However, this period was often not a true developmental period because it was found that, instead of emerging within a day or two after transforming to adult, as is the case with *grandis* in the Southern States, many of the weevils would remain in the cells for some days after becoming adult. This was particularly the case during the latter part of the season.

In watching for the emergence of adults each lot of squares was examined daily for about 20 days after egg deposition and then was examined only occasionally. In this way the dates of emergence were secured when the weevils emerged shortly after becoming adults, but late in the season many emerged after the daily observations had been stopped and consequently no figures were secured on their time of emergence. As this delayed emergence did not become usual with the weevils until those from eggs deposited after the 1st of September had developed, the data have been divided at this date and are given in Tables V and VI.

The figures in Table V are probably very nearly those for a developmental period such as is experienced by the Texas cotton boll weevils and the periods are surprisingly similar to those of cotton boll weevils. It is interesting to note that the average developmental period of both sexes of *thurberiae* in Arizona was 15.4 days while in southern Texas it was 18.5 days. It seems probable that nearly all of the weevils included in Table VI delayed emergence. This was probably due to the approach of the time for entering hibernation. From the squares receiving eggs before September 1, 71 weevils emerged in normal time and 2 were retarded, while from those receiving eggs after this date 10 emerged more or less normally and 48 were retarded.

In this series 1,260 squares containing eggs were observed and these produced 145 weevils, including those found in the cells. In other words, only 11.5 per cent of the squares receiving eggs produced adults. This is a very low percentage and seems to indicate that the cotton squares are not completely suited to the development of the Arizona weevil.

TABLE V.—*Developmental period of Anthonomus grandis thurberiae in cotton squares, Arizona, 1914; eggs deposited before Sept. 1.*

Date eggs deposited.	Date adults emerged.	Males.			Females.			Adult emerged but date not noted.	Stages found upon examination of squares.
		Period.	Number weevils.	Weevil days.[1]	Period.	Number weevils.	Weevil days.[1]		
		Days.			*Days.*				
July 6	July 24	18	1	18	.....	.....	.....	.....	
7	July 25	18	1	18	18	1	18	.....	
8	July 22	.....	.....	.....	14	1	14	.....	
9	July 23	14	1	14	14	2	28	.....	
9	July 24	15	1	15	.....	.....	.....	.....	
11	July 25	.....	.....	.....	14	1	14	.....	
11	July 26	.....	.....	.....	15	1	15	.....	
12	July 25	13	2	26	.....	.....	.....	.....	
12	July 28	16	1	16	.....	.....	.....	.....	
13	...do.....	15	1	15	.....	.....	.....	.....	
14	July 27	13	1	13	.....	.....	.....	.....	
14	July 28	.....	.....	.....	14	1	14	.....	
14	Aug. 1	.....	.....	.....	18	1	18	.....	
15	July 29	14	3	42	14	1	14	.....	1 adult died in cell without emerging.
15	July 30	15	1	15	15	1	15	.....	
15	Aug. 1	17	1	17	.....	.....	.....	.....	
16	July 29	13	1	13	.....	.....	.....	.....	
16	July 30	14	1	14	14	2	28	.....	Do.
16	Aug. 1	16	2	32	16	2	32	.....	
16	Aug. 4	18	2	36	.....	.....	.....	.....	
17	Aug. 1	15	2	30	15	3	45	.....	1 male dead.
18	...do.....	.....	.....	.....	14	3	42	.....	1 adult dead in cell.
18	Aug. 3	.....	.....	.....	16	1	16	.....	
19	Aug. 2	14	1	14	14	1	14	.....	
19	Aug. 3	.....	.....	.....	15	2	30	.....	
19	Aug. 4	.....	.....	.....	16	1	16	.....	
20	Aug. 3	14	1	14	14	2	28	.....	
23	Aug. 7	15	1	15	.....	.....	.....	.....	
23	Aug. 11	.....	.....	.....	19	1	19	.....	
24	Aug. 8	15	1	15	.....	.....	.....	.....	
24	Aug. 10	17	1	17	17	1	17	.....	
24	Aug. 13	20	1	20	.....	.....	.....	[2] 1	
25	Aug. 7	13	1	13	.....	.....	.....	.....	
25	Aug. 10	16	1	16	16	2	32	.....	
25	Aug. 12	.....	.....	.....	18	1	18	.....	
27	.....	.....	.....	.....	.....	.....	.....	[3] 1	
28	Aug. 12	15	1	15	.....	.....	.....	.....	
30	Aug. 17	18	1	18	.....	.....	.....	.....	
Aug. 1	...do.....	16	1	16	.....	.....	.....	.....	
1	Aug. 18	.....	.....	.....	17	1	17	.....	
2	Aug. 21	19	1	19	.....	.....	.....	.....	
3	Aug. 19	16	1	16	.....	.....	.....	.....	
3	Aug. 20	17	1	17	.....	.....	.....	.....	
11	Aug. 30	19	1	19	.....	.....	.....	.....	
28	Sept. 11	14	1	14	.....	.....	.....	.....	
Total	.....	.....	38	592	.....	33	504	2	4.
Average	.....	.....	.....	15.6	.....	.....	15.3	.....	
Total weevils of both sexes.				71				.....	
Average period for both sexes.				15.4				.....	

[1] "Weevil days" is the term applied to the sum of the time periods experienced by the various individuals during the course of the observations.
[2] Female.
[3] Male.

At the close of the experiment in November all squares were examined and the following stages were found remaining in them: 9 dead adults, 5 live adults, 7 live pupæ, and 12 live larvæ. The live adults were found only in squares receiving eggs after October 14, so it is quite possible that they would still have emerged. The immature stages were in the later lots of squares and probably had not had time to become adult.

TABLE VI.—*Developmental period of Anthonomus grandis thurberiae in cotton squares, Arizona, 1914; eggs deposited after Sept. 1.*

Date eggs deposited.	Date adults emerged.	Males.			Females.			Adult emerged but date not noted.	Stages found upon examination of squares.
		Period.	Number weevils.	Weevil days.	Period.	Number weevils.	Weevil days.		
		Days.			*Days.*				
Sept. 1								1 male	
2								1 female	
11								2 females	
12								3 males and 2 females.	
16								1 weevil	
17	Oct. 3	18	2	36	18	1	18		
19	Oct. 21	32	1	32				1 female	
21								2 males and 3 females.	1 female dead.
23								1 male and 2 females.	
29	Oct. 21	22	2	44	22	2	44	4 males and 1 female.	
Oct. 1	...do	20	1	20				1 male and 2 females.	
3	Oct. 22	19	1	19				3 females	
5								2 males and 4 females.	2 females and 1 male dead.
7								2 males and 1 female.	
9								1 male and 1 female	
12								1 weevil	
14								2 males and 3 females.	2 females and 1 male alive.
16								1 female	1 female alive.
19								1 male and 1 female	
21									1 teneral male, 4 pupæ, and 1 larva alive.
23									2 pupæ and 1 larva alive in cells Nov. 9.
26									1 pupa and 3 larvæ alive in cells Nov. 9.
28									2 larvæ alive in cells Nov. 9.
31									3 larvæ alive in cells Nov. 9.
Nov. 2									2 larvæ alive in cells Nov. 9.
Total			7	151		3	62		
Average				21.5			20.6		
Total weevils of both sexes.				10					
Average period, both sexes.				21.3					

In the examination of these squares a great number of the nonproducing ones were found to have the contents more or less eaten by weevil larvæ. These larvæ were evidently unable to survive upon this food. Of course the larval mortality is quite high in any breeding series of either *grandis* or *thurberiae* regardless of the food, but this is certainly higher than usual.

IN COTTON BOLLS.

The developmental period of the weevil in cotton bolls was studied in the same manner as that just described for cotton squares. The results of this series are given in Table VII.

TABLE VII.—*Developmental period of Anthonomus grandis thurberiae in cotton bolls, Agua Caliente ranch, Arizona, 1914.*

Date eggs deposited.	Date adults emerged.	Males.			Females.			Condition found at examination of bolls at close of experiment on Nov. 10, 1914.
		Period.	Number weevils.	Weevil days.	Period.	Number weevils.	Weevil days.	
		Days.			*Days.*			
July 13	July 30	17	1	17				
23								1 live female in cell, 2 dead larvæ.
24								1 live female, 2 pupæ, and 1 larva dead.
25								1 live and 1 dead adult in cells.
27	Aug. 17	21	1	21				1 dead adult in cell.
28								Do.
30								Do.[1]
Aug. 1								Do.[1]
2	Aug. 25	23	1	23				1 male has emerged.
4								1 dead adult in cell.[1]
7	Sept. 4				28	1	28	Do.[1]
13								1 live pupa in cell.
20	Sept. 7				18	1	18	
24								1 dead adult in cell.[1]
28								1 female emerged before Sept. 22.
30								3 dead adults in cells.
31								1 male alive and 1 female dead in cells.
Sept. 1	Sept. 22	21	1	21	21	1	21	1 female alive, 2 adults dead.
2								1 male alive in cell.
3								1 male emerged, 1 adult and pupa dead.
4								1 male alive in cell.
11								2 adults dead.
12								1 live female.
14								1 male has emerged.
17								1 male, 1 female emerged; 1 male alive.
19								2 adults alive, 2 adults dead.
21								3 males emerged, 1 male alive in cell.
23								2 males emerged, 3 adults alive in cell; 1 male dead in cell.
27								1 male emerged, 1 male and 1 female alive in cell, 1 male dead in cell.
29								2 males alive in cell.
Oct. 1								1 female emerged, 2 males and 1 female alive in cell, 1 larva alive in cell.
3								1 female emerged, 1 adult dead in cell.
5								3 weevils alive in cells.
7								2 adults alive in cells.
9								2 adults and 2 pupæ alive in cells.
12								2 adults alive in cells.
14								1 weevil and 1 larva alive.
16								4 pupæ and 1 larva alive in cell.
19								2 pupæ and 1 larva alive in cell.
Total			4	82		3	67	
Average				20.5			22.3	
Total weevils, both sexes				7				
Average period, both sexes				21.4				

[1] These adults were evidently killed by proliferation.

From this table it is seen that the results of rearings in cotton bolls differ very widely from those in cotton squares. The most marked difference is in the tendency exhibited by the weevils to remain in hibernation in the cells in the bolls. In fact, only seven weevils emerged directly after what might be termed a normal developmental period.

All bolls were retained, and at the close of the experiments on November 10 all were opened and the contents noted. This examination showed that 15 adults had emerged after observations were stopped, 33 adults were alive in cells, 22 adults were dead in cells, 9 pupæ were alive in cells, 4 larvæ were alive in cells, and 3 larvæ were dead in cells. Thus it is seen that 22 adults emerged, 33 remained alive in the cells, and 22 died in them.

The developmental period for the seven weevils which were observed at the time of emergence varied from 17 to 28 days, with an average of 21.4 days. In Texas the Thurberia weevils averaged 25 days in cotton bolls. They displayed the same tendency to delay emergence some days after maturity but did not attempt to hibernate in the cell as in Arizona.

Many of the records point to the great irregularity of the development in cotton bolls. In one case where the egg was deposited August 13 a live pupa was found in the boll on November 10, or a total of 58 days for incubation plus larval plus part of pupal period. In another case where the egg was deposited October 1 a live larva was found November 10, or a total of 40 days for incubation plus part of larval period. When it is remembered that under the same conditions adults were produced and emerged in as few as 17 days after egg deposition, these records are all the more striking.

The death of the adults due to proliferation is quite interesting. Five were found which were quite evidently killed by this agency. In these cases the weevils had formed more or less normal pupal cells, but the growth of the tissue broke these and pressed the adults to death. Of course, there was no way to determine how many of the immature stages were killed by this phenomenon, but the number was probably quite high.

IN THURBERIA BOLLS.

The Thurberia bolls containing eggs secured in the different series of weevils fed upon this food were placed on moist sand in tumblers and an attempt made to rear adults. In such tests the bolls were always as green and fresh as possible and were selected as seeming best adapted for larval food. Early in the investigation it was quite apparent that a single moistening of the sand in the tumbler would not suffice to keep the boll fit for larval food through the developmental period, so the sand was moistened frequently. In this way what seemed to be the best conditions for development were secured, but, in spite of this, the attempt was almost a total failure.

Thirty bolls containing many eggs deposited from June 30 to October 16 were observed, and only one weevil emerged from the entire lot. This was a male which emerged October 31 from a boll which had received an egg October 1, giving a total period from

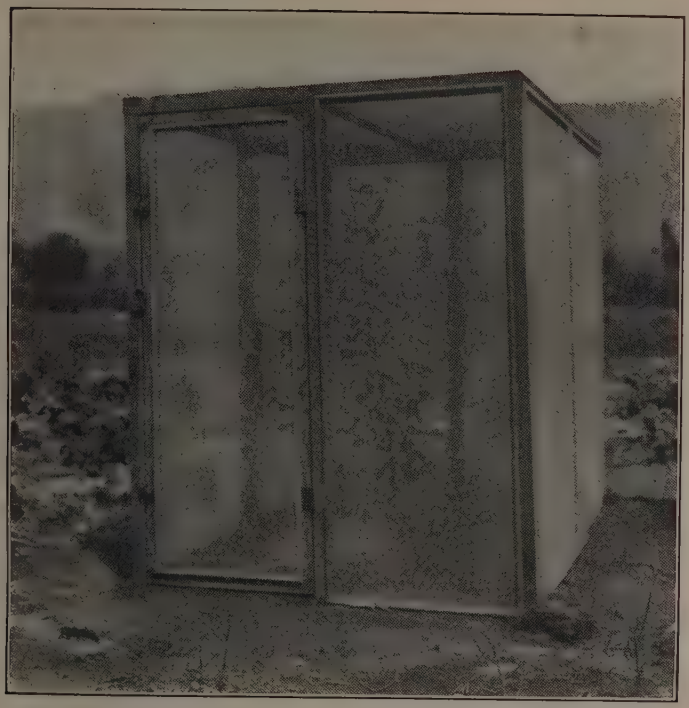

FIG. 1.—CAGED THURBERIA PLANTS INFESTED WITH WEEVILS. (ORIGINAL.)

FIG. 2.—CAGES OVER COTTON PLANTS USED IN STUDIES ON WEEVIL ACTIVITY. (ORIGINAL.)

TYPES OF REARING CAGES SIMULATING NATURAL CONDITIONS, USED IN STUDIES ON THE BIOLOGY OF THE ARIZONA WILD COTTON WEEVIL.

deposition to adult emergence of 31 days. At the close of the experiment all bolls were opened and the contents examined. Almost all of them showed not the slightest signs of weevil larval work and only one weevil stage was found. This was a pupa found November 9 in a boll which received an egg October 14.

Thurberia buds were tested in the same manner several times during the season but always with negative results. In fact, it was found exceedingly difficult to induce the weevils to deposit in them.

TESTS OF CAGED WEEVILS ON GROWING PLANTS.

ON THURBERIA PLANTS.

In order to study the activities of the weevils upon Thurberia plants in the field, a large cage was arranged over a plant growing under cultivation at the ranch. (Pl. II, fig. 1.) The plant was nearly 5 feet tall and well laden with buds, blooms, and bolls.

Two male and two female weevils were removed from hibernation cells in the Thurberia bolls August 30 and fed upon Thurberia buds and leaves in captivity until September 14. They were then released in the cage with the growing Thurberia plant.

On September 17 two small buds had fallen to the ground with feeding punctures. On the 21st 6 small bolls, 3 buds, and 2 blooms had fallen, all fed upon by the weevils. Several of the fallen bolls and many still hanging on the plant contained egg punctures.

On October 2 it was noted that a very large proportion of the bolls of the plant had been punctured and many contained eggs or larvæ, but very few squares had been attacked.

The plant stopped blooming about October 10, and at this time many of the bolls had the purplish color characteristic of those infested. No bolls were on the ground, and a rather violent shaking of the plant failed to cause any to drop. On October 31 one male weevil was found active on the roof of the cage. A very careful examination of the plant and trash in the cage failed to reveal any other weevils. The infested bolls were still hanging on the plant.

On January 2, 1915, all bolls were removed from this plant and the cage examined for weevils. No adults, either alive or dead, were found in the trash or on the cage walls. All bolls were examined and the following contents noted: 271 bolls taken from the plant were examined; 123 were uninjured, 115 were injured but contained no weevil stages, 30 contained live adults, and 3 contained 1 dead larva, 1 dead pupa, and 1 dead adult, respectively. Eight bolls found on the ground were examined and 6 were found to show signs of weevil injury, but no stages were present. Of the total of 279 bolls examined, 154 had been injured more or less by the weevils, or an infestation of 55.2 per cent. This indicates what was certainly a great activity on the part of the two females.

The fact that while 154 bolls showed signs of weevil injury, only 30 (19.4 per cent) contained live adults on January 2, indicates a very high larval mortality. Most of the injured bolls containing no stages showed only one or two seeds eaten out by larvæ, though in some the injury was more extensive. Whether or not this high larval mortality is found in nature is open to doubt, but the cage conditions very closely approximated those under which the lower plants and weevils exist. This larval mortality may explain one puzzling point in connection with the interrelation of the Thurberia plant and weevil—that is, why the weevil does not multiply entirely out of proportion to the abundance of its very restricted host plant when the females are evidently so extremely prolific in egg deposition.

ON COTTON PLANTS.

In the same manner that these weevils were tested upon growing Thurberia plants, others were tested on growing cotton plants. Five cages, three large and two small, were placed over rows of plants about 16 inches tall. These plants were all bearing squares, blooms, and bolls. A general view of these cages is shown in Plate II, figure 2. All weevils were collected feeding on Thurberia in the Santa Rita Mountains September 25 and kept without food for four days.

The weevils were introduced into the various cages September 29. The small cages (Nos. 8 and 9) each received two males and two females while the large cages (Nos. 3, 6, and 7) each received four of each sex. Following the introduction of these weevils the cages were examined frequently until October 31. The following is a summary of the injured forms which fell from the plants during this period:

Cage No. 8, 11 small bolls.
Cage No. 9, 14 small bolls, 2 squares.
Cage No. 3, 22 small bolls, 2 squares, and 1 bloom.
Cage No. 6, 13 small bolls, 3 squares, and 1 bloom.
Cage No. 7, 18 small bolls, 1 square.

It is interesting to note that all the egg deposition was in the bolls. In fact there was only a comparatively small amount of feeding on the squares and little more on the blooms. For egg deposition the female seems to prefer bolls from about one-fourth to one-third grown. Some of the smallest of these drop from the plant when the larval injury becomes severe but nearly all remain hanging.

On October 31 a final examination of all cages was made. At this time the leaves and other trash piled in the cage was examined for hibernating adults and the plants were examined for active ones. One weevil was found active on the wall of a cage, one was feeding on a bloom, and one was dead inside the bracts of a boll. One male and one female, both dead, were found at the bottom of a pile of trash.

On January 2, 1915, all bolls were collected from the cages and examined for weevil injury or stages. The results are shown in Table VIII.

TABLE VIII.—*Weevil stages found in cotton bolls taken from caged plants, Jan. 2, 1915.*

Cage No.	Bolls.		Live weevil stages.			Dead weevil stages.		
	Not injured.	Injured but no weevil stages present.	Larvæ.	Pupæ.	Adults.	Larvæ.	Pupæ.	Adults.
9	15	1						
8	7	8						
3	11	16		2	3			
6	5	7	2	1	4		1	
7	6	2	1	1	6		1	
Total	44	34	3	4	13		2	

The fact that only two weevils had emerged, both from fallen bolls, indicated the strong adherence of the weevil to the cell hibernation habit, even when transferred to cotton. One of the weevils which had emerged was found active on the ground and, judging from its condition, it had emerged only a short time before collection. A comparison of the number of immature stages found in these cotton bolls with that found in Thurberia bolls in a similar cage test shows the retarded development under the unnatural conditions of a cotton boll.

PARASITES AND PREDATORY ENEMIES OF THE WEEVIL.

In the course of the season's investigations several hundred infested Thurberia bolls were collected at various points in the Santa Catalina and Santa Rita Mountains and the adult weevils were reared. In spite of the great number of these bolls which were utilized, not a single parasite emerged. Not a record of weevil parasitism was made by the writer during the entire season.

Only one case of predaceous insects attacking *thurberiae* was noted. On September 25 in the arroyo below Saw Mill Canyon, Santa Rita Mountains, at about 3,500 feet altitude, three Phymatidæ were observed feeding on adult weevils. These have been determined by Mr. Otto Heidemann as *Phymata erosa* var. *fasciata* Gray (one female) and *Macrocephalus inequalis* Champ. (two males). The latter of these was the more abundant at this time.

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